

WHAT IS CLAIMED IS:

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1. A magnetoresistive sensor comprising:
a first conductor layer;
a free ferromagnetic layer provided on said first conductor layer;
a nonmagnetic intermediate layer provided on said free ferromagnetic layer;
a pinned ferromagnetic layer provided on said nonmagnetic intermediate layer;
an antiferromagnetic layer provided on said pinned ferromagnetic layer; and
a second conductor layer provided on said antiferromagnetic layer;
wherein at least one of said free ferromagnetic layer and said pinned ferromagnetic layer has a thickness larger than that providing a maximum resistance change rate or resistance change amount in the case of passing a current in an in-plane direction.

2. A magnetoresistive sensor according to claim 1, wherein the thickness of at least one of said free ferromagnetic layer and said pinned ferromagnetic layer falls in the range of 0.5 to 2.0 times the mean free path of conduction electrons in a spin direction not spin-dependently scattered in a magnetization direction of

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said at least one layer.

3. A magnetoresistive sensor according to claim 2, wherein the thickness of at least one of said free ferromagnetic layer and said pinned ferromagnetic layer falls in the range of 3 nm to 12 nm.

4. A magnetoresistive sensor according to claim 1, wherein said pinned ferromagnetic layer has a laminated ferri structure.

5. A magnetoresistive sensor according to claim 1, wherein said free ferromagnetic layer has a laminated ferri structure.

6. A magnetoresistive sensor according to claim 1, wherein said nonmagnetic intermediate layer has a thickness larger than that providing a maximum resistance change rate or resistance change amount in the case of passing a current in an in-plane direction.

7. A magnetoresistive sensor according to claim 5, wherein said nonmagnetic intermediate layer is formed of Cu, and has a thickness falling in the range of 4 nm to 6 nm.

8. A magnetoresistive sensor according to claim 3, wherein said free ferromagnetic layer and said pinned ferromagnetic layer are formed of a material selected from the group consisting of Co, CoFe, CoFeB, and NiFe.

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9. A magnetoresistive sensor comprising:
a first conductor layer;
a first antiferromagnetic layer provided on said first conductor layer;
a first pinned ferromagnetic layer provided on said first antiferromagnetic layer;
a first nonmagnetic intermediate layer provided on said first pinned ferromagnetic layer;
a free ferromagnetic layer provided on said first nonmagnetic intermediate layer;
a second nonmagnetic intermediate layer provided on said free ferromagnetic layer;
a second pinned ferromagnetic layer provided on said second nonmagnetic intermediate layer;
a second antiferromagnetic layer provided on said second pinned ferromagnetic layer; and
a second conductor layer provided on said second antiferromagnetic layer.

10. A magnetoresistive sensor according to claim 9, wherein at least one of said first pinned ferromagnetic layer, said second pinned ferromagnetic layer, and said free ferromagnetic layer has a thickness falling in the range of 3 nm to 12 nm.

11. A magnetoresistive sensor according to claim

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10, wherein said first and second pinned ferromagnetic layers and said free ferromagnetic layer are formed of a material selected from the group consisting of Co, CoFe, CoFeB, and NiFe.

12. A magnetoresistive sensor according to claim 9, wherein at least one of said first and second pinned ferromagnetic layer and said free ferromagnetic layer has a laminated ferri structure.

13. A magnetoresistive sensor according to claim 9, wherein each of said first and second nonmagnetic intermediate layers is formed of Cu, and has a thickness falling in the range of 4 nm to 6 nm.

14. A magnetoresistive sensor comprising:

a first conductor layer;

a first free ferromagnetic layer provided on said first conductor layer;

a first nonmagnetic intermediate layer provided on said first free ferromagnetic layer;

a first pinned ferromagnetic layer provided on said first nonmagnetic intermediate layer;

an antiferromagnetic layer provided on said first pinned ferromagnetic layer;

a second pinned ferromagnetic layer provided on said antiferromagnetic layer;

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a second nonmagnetic intermediate layer provided on said second pinned ferromagnetic layer;

a second free ferromagnetic layer provided on said second nonmagnetic intermediate layer; and

a second conductor layer provided on said second free ferromagnetic layer.

15. A magnetoresistive sensor having a first conductor layer, a second conductor layer, and a magnetoresistive film provided between said first and second conductor layers,

wherein said magnetoresistive film has a thickness larger than that providing a maximum resistance change rate or resistance change amount in the case of passing a current in an in-plane direction.

16. A magnetoresistive sensor according to claim 15, wherein said magnetoresistive film comprises a spin valve film having a free ferromagnetic layer and a pinned ferromagnetic layer; and

at least one of said free ferromagnetic layer and said pinned ferromagnetic layer has a thickness larger than that providing a maximum resistance change rate or resistance change amount in the case of passing a current in an in-plane direction.

17. A magnetoresistive head for reproducing

information recorded on a recording medium, comprising:

a first electrode terminal;

a spin valve magnetoresistive element provided on said first electrode terminal at a position retracted from a medium opposing surface of said head, for converting a change in signal magnetic field leaked from said recording medium into a resistance change;

a first flux guide having one end exposed to said medium opposing surface and another end overlapping one end of said spin valve magnetoresistive element, for guiding a magnetic flux from said recording medium to said spin valve magnetoresistive element;

a second flux guide having one end overlapping the other end of said spin valve magnetoresistive element; and

a second electrode terminal provided on said spin valve magnetoresistive element.

18. A magnetoresistive head according to claim 17, wherein said spin valve magnetoresistive element comprises a free ferromagnetic layer provided on said first electrode terminal, a nonmagnetic intermediate layer provided on said free ferromagnetic layer, a pinned ferromagnetic layer provided on said nonmagnetic intermediate layer, and an antiferromagnetic layer

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a first magnetic shield provided below said first electrode terminal; and

said second flux guide and said first magnetic shield being magnetically connected through a flux path.

22. A magnetoresistive head according to claim 21, wherein the other of said first and second electrode terminals is in contact with a part of another film surface of said spin valve magnetoresistive element, and said first and second electrode terminals have

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substantially the same size.

23. A magnetoresistive head according to claim 17, further comprising magnetic domain control films provided on the opposite sides of said spin valve magnetoresistive element;

each of said magnetic domain control films being formed from one of a high-coercivity film and an antiferromagnetic film.

24. A magnetoresistive head for reproducing information recorded on a recording medium, comprising:

a first magnetic shield;

an insulating layer provided on said first magnetic shield;

a spin valve magnetoresistive element provided on said insulating layer at a position retracted from a medium opposing surface of said head, for converting a change in signal magnetic field leaked from said recording medium into a resistance change;

a first flux guide having one end exposed to said medium opposing surface and another end overlapping one end of said spin valve magnetoresistive element, for guiding a magnetic flux from said recording medium to said spin valve magnetoresistive element;

a second flux guide having one end in contact with

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the other end of said spin valve magnetoresistive element;

an electrode terminal provided on said spin valve magnetoresistive element;

a second magnetic shield provided on said electrode terminal; and

a flux path for connecting said second flux guide and said first magnetic shield.

25. A magnetoresistive head according to claim 24, wherein said spin valve magnetoresistive element comprises a free ferromagnetic layer provided on said insulating layer in partial contact with said one end of said second flux guide, a nonmagnetic intermediate layer provided on said free ferromagnetic layer, a pinned ferromagnetic layer provided on said nonmagnetic intermediate layer, and an antiferromagnetic layer provided on said pinned ferromagnetic layer.

26. A magnetoresistive head according to claim 24, wherein said electrode terminal is in contact with a part of a film surface of said spin valve magnetoresistive element, and said electrode terminal is smaller in size than said spin valve magnetoresistive element in said film surface.

27. A magnetoresistive head according to claim 24,

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further comprising a nonmagnetic layer provided on said insulating layer and between said first and second flux guides;

said spin valve magnetoresistive element being provided on said nonmagnetic layer.

28. A spin valve magnetoresistive head according to claim 24, further comprising magnetic domain control films provided on the opposite sides of said spin valve magnetoresistive element;

each of said magnetic domain control films being formed from one of a high-coercivity film and an antiferromagnetic film.

29. A magnetoresistive sensor comprising:

a first antiferromagnetic layer;

a pinned ferromagnetic layer provided on said first antiferromagnetic layer;

a nonmagnetic intermediate layer provided on said pinned ferromagnetic layer;

a free ferromagnetic layer provided on said nonmagnetic intermediate layer; and

a second antiferromagnetic layer provided on said free ferromagnetic layer for performing magnetic domain control of said free ferromagnetic layer by an exchange bonding force;

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wherein a portion of said second antiferromagnetic layer contacting a magnetic field sensing portion of said free ferromagnetic layer is formed of a compound of constituent elements of said second antiferromagnetic layer and a reactive element selected from the group consisting of fluorine and chlorine.

30. A magnetoresistive sensor according to claim 29, wherein said second antiferromagnetic layer is formed of an alloy of manganese and another metal element.

31. A magnetoresistive sensor according to claim 29, wherein said second antiferromagnetic layer is formed of an alloy selected from the group consisting of NiMn, PtMn, PdPtMn, and IrMn.

32. A manufacturing method for a magnetoresistive sensor, comprising the steps of:

forming a first antiferromagnetic layer;

forming a pinned ferromagnetic layer on said first antiferromagnetic layer;

forming a nonmagnetic intermediate layer on said pinned ferromagnetic layer;

forming a free ferromagnetic layer on said nonmagnetic intermediate layer;

forming a second antiferromagnetic layer for performing magnetic domain control of said free

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ferromagnetic layer by an exchange bonding force, on said free ferromagnetic layer; and

applying a reactive element selected from the group consisting of fluorine and chlorine to a portion of said second antiferromagnetic layer contacting a magnetic field sensing portion of said free ferromagnetic layer to thereby form a compound of constituent elements of said second antiferromagnetic layer and said reactive element at said portion of said second antiferromagnetic layer.

33. A magnetoresistive head comprising:

a lower electrode;

a magnetoresistive film provided on said lower electrode;

magnetic domain control films provided on the opposite sides of said magnetoresistive film;

an upper electrode provided on said magnetoresistive film and said magnetic domain control films; and

a planarizing film provided between said upper electrode and said lower electrode so as to embed said magnetoresistive film and said magnetic domain control films.

34. A magnetoresistive head according to claim 33, further comprising a protective film provided between

said magnetoresistive film and said upper electrode, said protective film having a thickness not less than 1/2 of the thickness of said magnetoresistive film.

35. A magnetoresistive head according to claim 34, wherein said protective film is formed of a soft magnetic material.

36. A magnetoresistive head according to claim 33, wherein said planarizing film is formed from an insulating magnetic film.

37. A magnetoresistive head according to claim 36, wherein said insulating magnetic film is formed of ferrite.

38. A magnetoresistive head according to claim 33, wherein said planarizing film has a laminated structure composed of a conductive film and a nonmagnetic insulating film.

39. A magnetoresistive head according to claim 38, wherein said magnetic domain control films are formed from a CoCrPt film, and said nonmagnetic insulating film is formed from an SiO₂ film or an Al₂O₃ film.

40. A magnetoresistive head according to claim 33, wherein at least one of said lower electrode and said upper electrode is formed from a soft magnetic film.

41. A magnetoresistive head according to claim 33,

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wherein said magnetoresistive film is selected from the group consisting of a spin valve film, a tunnel magnetoresistive film, and an artificial lattice film.

42. A manufacturing method for a magnetoresistive head, comprising the steps of:

sequentially laminating a lower electrode, a magnetoresistive film, and a protective film formed of a soft magnetic material on a substrate;

performing first etching of said magnetoresistive film and said protective film into a given shape;

depositing a planarizing film including a magnetic domain control film over said substrate;

performing first planarization of said planarizing film to fill a portion removed by said first etching with said planarizing film by using a planarization technique;

performing second etching of said magnetoresistive film, said protective film, and said planarizing film into a given shape after said first planarization;

depositing an insulating film over said substrate;

performing second planarization of said insulating film to fill a portion removed by said second etching with said insulating film by using the planarization technique; and

depositing an upper electrode over said substrate

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to bring said upper electrode into contact with said protective film.

43. A manufacturing method according to claim 42, wherein said planarization technique is selected from the group consisting of a chemical-mechanical polishing process, a lapping process, and an etchback process.